Coastal Ecosystems Section

MEMORANDUM

TO: Susan Gray, Bureau Chief, Applied Sciences
Lawrence Glenn, Section Administrator, Coastal Ecosystems Section

THROUGH: Cassondra Armstrong, Science Supervisor, Coastal Ecosystems Section

FROM: Don Medellin, Principal Scientist, Coastal Ecosystems Section

DATE: October 10, 2018

SUBJECT: **Caloosahatchee River MFL Rule Revisions and Additional Science Documentation**

A document entitled, *Technical Document to Support the Reevaluation of the Minimum Flow Criteria for the Caloosahatchee River Estuary* (Technical Document) was produced in January 30, 2018, that outlines a 2017 reevaluation of the minimum flow and minimum water level (MFL) criteria. The MFL was initially adopted for the Caloosahatchee River in 2001 and reevaluated in 2003 (Subsection 40E-8.221(2), Florida Administrative Code [F.A.C.]). The 2018 reevaluation included new information obtained and analyses completed since 2003, which support revision of the existing MFL criteria contained in the rule. Revised MFL criteria were included in the technical document along with the basis for their development. The MFL technical document also included the findings of an independent scientific peer review panel that found the document, modeling and assumptions, technical analyses, methodologies, and the proposed revised criteria were scientifically sound and well supported.

Subsequent to the release of the MFL technical document, public comments and concerns were received regarding the proposed MFL criteria. Therefore, additional analyses and modeling were conducted in 2018, during the rule development process, to further evaluate and refine the MFL criteria, and the new criteria were incorporated into a revised draft MFL rule. The purpose of this memo is to document the additional analyses conducted and criteria revisions made since January 30, 2018.

MFL Criteria Revisions as of January 30, 2018 (Initial Revisions):

Figure 1 shows the initially proposed revisions to the MFL criteria that were outlined in the Technical Document and reviewed by the peer review panel in 2017.

40E-8.221 Minimum Flows and Levels (MFLs): Surface Waters.

(2) Caloosahatchee River. The MFL for the Caloosahatchee River is the 30-day moving average flow of 400 cubic feet per second (cfs) at S-79. ~~A minimum mean monthly flow of 300 CFS is necessary to maintain sufficient salinities at S-79 in order to prevent a MFL exceedance. A MFL exceedance occurs during a 365-day period, when:~~

(a) A MFL exceedance occurs during a 365-day period when the 30-day moving average flow at S-79 is below 400 cfs and the daily average salinity has exceeded 10 at the Ft. Myers salinity monitoring station (located at latitude 26° 38' 57.84" N, longitude 81° 52' 5.68" W) for more than 55 consecutive days. Salinity at the Ft. Myers salinity monitoring station shall be measured at 20% of the total river depth at mean low water. ~~A 30-day average salinity concentration exceeds 10 parts per thousand at the Ft. Myers salinity station (measured at 20% of the total river depth from the water surface at a location of latitude 263907.260, longitude 815209.296); or~~

(b) A MFL violation occurs when a MFL exceedance occurs more than once in a 5-year period ~~A single, daily average salinity exceeds a concentration of 20 parts per thousand at the Ft. Myers salinity station. Exceedance of either paragraph (a) or (b), for two consecutive years is a violation of the MFL.~~

Figure 1. Initially proposed revision of Caloosahatchee MFL criteria shown in the MFL Technical Document and reviewed by the peer review panel in 2017. Strike through indicates deletions; underlining indicates insertions.

Rule Development and Further MFL Criteria Revisions:

The District received feedback on the proposed MFL revisions shown in **Figure 1** during two public rulemaking workshops held on February 15 and June 1, 2018, in Fort Myers; at a technical meeting held on May 7, 2018, also in Fort Myers; and through written comments received from stakeholders. Feedback included concerns about the flow, duration, return frequency components of the proposed MFL criteria, effects of the criteria on the low salinity zone and resource survival, and effects of high salinity events on other ecological indicators not addressed in the reevaluation, among others. One of the primary concerns of stakeholders was the duration component of the proposed salinity criterion (salinity > 10 for ≥ 55 consecutive days), which stakeholders believed would result in 70% of the protected resource being lost. Further dialogue with stakeholders indicated a lack of clarity on the difference between system restoration versus "recovery" pursuant to Section 373.0421(2)(a), Florida Statutes.

As a result of the feedback received, additional analyses, and modeling conducted since January 30, 2018, further revisions were made to the MFL criteria in Subsection 40E-8.221(2), F.A.C. (**Figure 2**). This draft MFL rule with revised criteria was brought before the South Florida Water Management District (SFWMD or District) Governing Board on July 12, 2018, for authorization to move forward with MFL rule revision through publication of a Notice of Proposed Rule.

40E-8.221 Minimum Flows and Levels (MFLs): Surface Waters.

(2) Caloosahatchee River. The MFL for the Caloosahatchee River is the 30-day moving average flow of 400 cubic feet per second (cfs) at S-79. ~~A minimum mean monthly flow of 300 CFS is necessary to maintain sufficient salinities at S-79 in order to prevent a MFL exceedance. A MFL exceedance occurs during a 365-day period, when:~~

(a) A MFL exceedance occurs during a 365-day period when the 30-day moving average flow at S-79 is below 400 cfs and the 30-day moving average salinity exceeds 10 at the Ft. Myers salinity monitoring station (located at latitude 26° 38' 57.84" N, longitude 81° 52' 5.68" W). Salinity at the Ft. Myers salinity monitoring station shall be measured at 20% of the total river depth at mean low water. ~~A 30-day average salinity concentration exceeds 10 parts per thousand at the Ft. Myers salinity station (measured at 20% of the total river depth from the water surface at a location of latitude 263907.260, longitude 815209.296); or~~

(b) A MFL violation occurs when a MFL exceedance occurs more than once in a 5-year period ~~A single, daily average salinity exceeds a concentration of 20 parts per thousand at the Ft. Myers salinity station. Exceedance of either paragraph (a) or (b), for two consecutive years is a violation of the MFL~~.

Figure 2. Final proposed Caloosahatchee MFL rule criteria.
Strike through indicates deletions; underlining indicates insertions.

Additional Analyses Conducted During the Rule Development Process

The following sections document additional scientific analyses and modeling conducted since January 30, 2018, to address areas of concern noted by stakeholders, and to support the proposed revisions to the MFL criteria shown in **Figure 2**.

Dry Season Definition:

In the District's analyses of flow and salinity in the Technical Document, the "dry season" is defined as the period from November through April. Comments were received concerning the exclusion of the month of May from the dry season. It was felt that May is typically a very dry month when multiple MFL exceedances and violations occur and it should be included in the dry season. In response to this concern, the District reevaluated inflow at S-79, and surface salinity and average salinity at the Ft. Myers salinity monitoring station (MFL compliance point), for a 23-year period of record (1993–2016), both including May and excluding May in the dry season. Data were analyzed statistically with analysis of variance (ANOVA) and p-value calculation (**Table 1**) and the results showed no significant differences between the dry season with May versus the dry season without May in terms of inflow at S-79 and salinity at the Ft. Myers salinity monitoring station. Based on these results, no subsequent changes were made in the District's analyses with regard to exclusion of May in the dry season.

Table 1. Statistical analysis of inflow at S-79 and salinity at the Ft. Myers salinity monitoring station with and without May included in the dry season. (Note: N– sample size, POR – period of record, and SD – standard deviation.)

Effects of May on S-79 inflow (cfs) and salinity at Ft. Myers (S_{FtM}) from 1/1993 to 12/2016

	Dry (Nov-Apr)	DryMay (Nov-May)	ANOVA p-value
Flow at S-79			
Mean±SD	1393.0±2116.5	1347.4±2055.9	p = 0.274
Median	579.0	543.0	
N	4631	5406	
Surface Salinity			
Mean±SD	8.4±6.7	8.6±6.9	p = 0.076
Median	7.8	8.2	
N	4144	4858	
Average Salinity			
Mean±SD	8.9±6.7	9.1±6.8	p = 0.105
Median	8.9	9.2	
N	4185	4899	

"Dry" represents the standard SFWMD dry season from November to April.

"DryMay" is the standard dry season with the addition of all May data during the POR.

Environmental Indicators:

Stakeholders commented that the minimum flow for the waterbody should be based on the most sensitive species inhabiting the Caloosahatchee River Estuary (CRE). Peer review findings received in 2000, as part of the rulemaking process in 2001, suggested that *Vallisneria americana* (also known as *Vallisneria* or tape grass) might not be the only keystone species in the CRE, and more than one species could be used as valued ecosystem components (VECs) to calculate the MFL. The panel recognized uncertainties, weaknesses, deficiencies, and inadequacies inherent in the single *Vallisneria* VEC approach, especially given its limited scope and depth. The panel recommended that the minimum flows for the CRE should be set by a suite of considerations that are centered around, but are not limited to, the proposed *Vallisneria* VEC approach. In addition, an important consideration in the overall approach to setting the minimum flow is consideration of possible harm to the lower estuary components (below the *Vallisneria* zone). A reevaluation was conducted in 2003, which resulted in direction from the District Governing Board to conduct further research on multiple indicators.

The 2017 MFL reevaluation included a resource-based approach, which evaluated multiple ecological indicators throughout the CRE, including assessment of *Vallisneria* (modeling and observed data analysis), zooplankton, ichthyoplankton, benthic fauna, oyster habitat, blue crabs, small-toothed sawfish, as well as studies of CRE hydrodynamics, inflow versus salinity, and water quality. However, the 2017 peer review panel suggested developing even further studies of one or more additional VEC species in the CRE in greater detail, especially one that can further support MFL duration requirements, in case the main VEC species (*Vallisneria*) does not recover after the addition of the reservoir system to increase dry season flows. The low salinity clam, *Rangia* sp., was recommended by the panel as an additional VEC. The District will consider inclusion of *Rangia* sp. and other benthic organisms for future research/monitoring and future reevaluations of the CRE MFL.

Flow Contributions from Tidal Basin:
During the first rule development workshop in February 2018, more information was requested about water contributions to the CRE from the Tidal Basin during the dry season. To address this issue, the Tidal Caloosahatchee Subwatershed Model (WaSh) was used with 2012 land use data to simulate the surface water and groundwater inflows from the Tidal Basin from 1967 to 2012. The model was calibrated with measured atmospheric and hydrologic data from 2008 to 2010 and verified with data from 2011 to 2012. The monthly flow distribution is shown in the box plot in **Figure 3**. The monthly mean flow and median flow (in cubic feet per second [cfs]) contributions for each month are shown in **Table 2**.

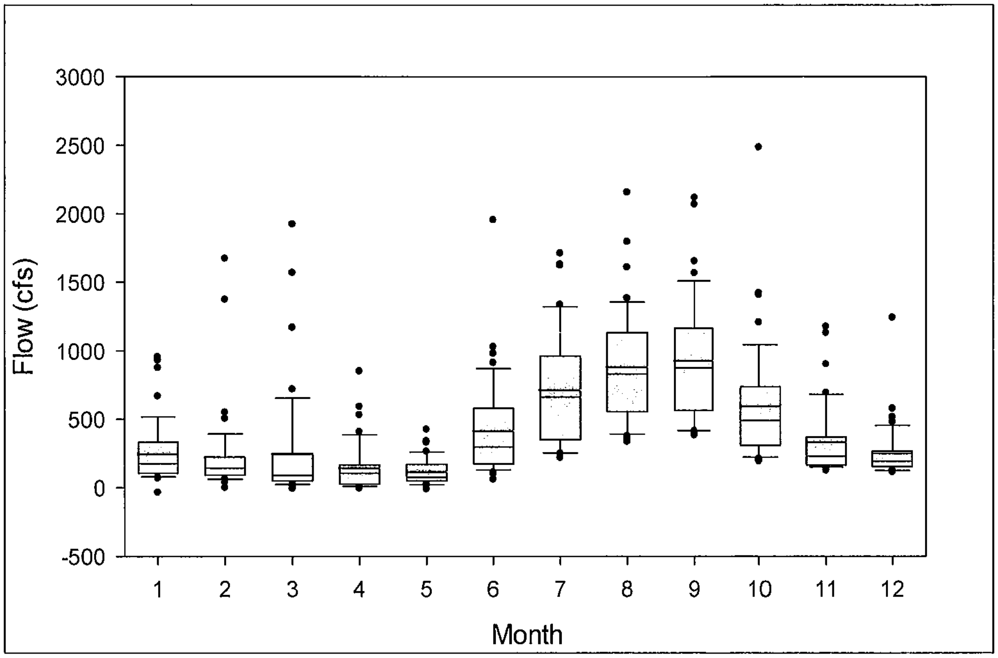


Figure 3. Box plot of the monthly distribution of flow (cfs) contributed by the Tidal Basin. The red line represents the mean flow while the black line represents the median flows.

Table 2. Monthly mean and median flow (cfs) contributions from the Tidal Basin.

	January	February	March	April	May	June	July	August	September	October	November	December
Mean	247.5	224.2	246.7	144.8	115.4	415.7	713.5	882.6	927.8	595.4	333.7	251.2
Median	176.2	143.8	90.5	105.8	76.7	298.9	662.4	831.8	873.8	488.5	230.0	192.8

Return Frequency:

Stakeholders expressed concerns about the ability to meet the proposed 5-year return frequency since exceedances occurred more than once in five years over the 39-year period of record used in the District's analysis of combined events of flow exceedance (30-day moving average flow at S-79 is below 400 cfs) and high salinity (daily average salinity is > 10 at the Ft. Myers salinity monitoring station for > 55 consecutive days). The 39-year period of record extended from January 1, 1967, to December 31, 2005.

To address stakeholder concerns about meeting the return frequency, the District performed an evaluation of long-term climatic records to determine if any anomalies had occurred during the 39-year period that could account for an exceedance return frequency of < 5 years. The results showed that combined flow exceedance and high salinity events occurred during six severe and extreme droughts from 1977 to 2001 (**Figure 4**). The exceedance events shown in the figure during 1977 to mid-1982 occurred at a frequency of < 5 years. Since MFLs are not intended to drought proof a system, it is probable that they will be exceeded during severe and extreme droughts. Therefore, no changes were made to the return frequency in the draft MFL rule (**Figure 2**).

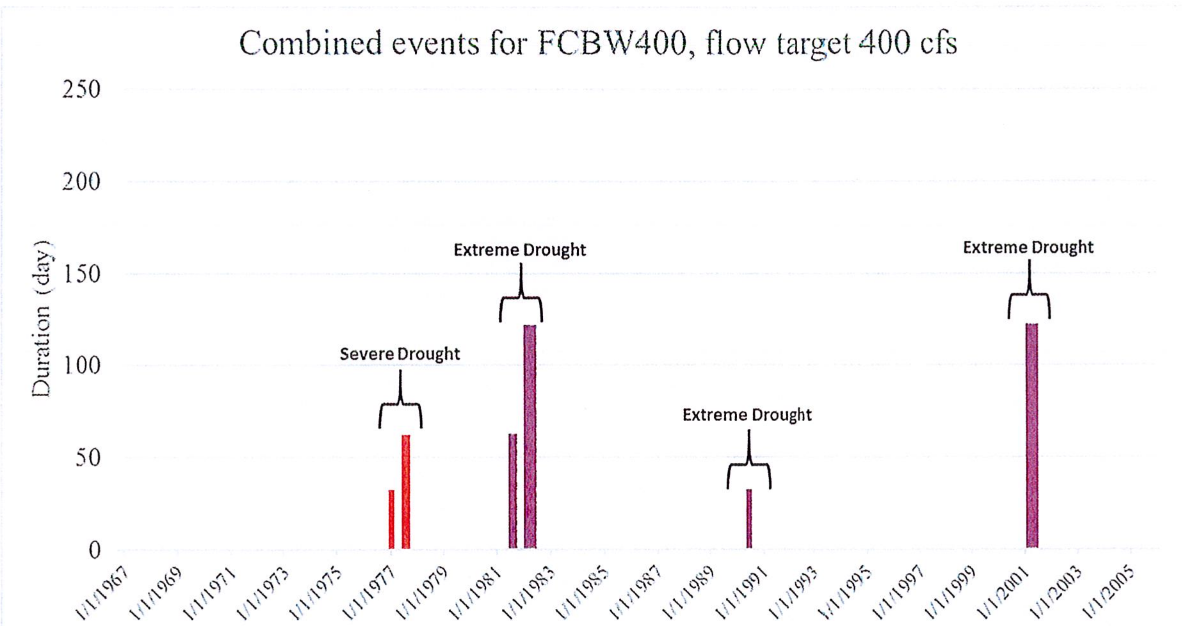


Figure 4. Occurrence and duration of combined flow exceedance events and high salinity events in the CRE during severe (red bars) and extreme (purple bars) droughts, per the Palmer Drought Severity Index (Palmer 1965). The width of the bar indicates the length of the drought. From the National Oceanic and Atmospheric Administration/National Centers for Environmental Information at https://www.ncdc.noaa.gov/temp-and-precip/drought/historical-palmers/psi/200201-200312.

Duration:

The duration component of the initially revised MFL criteria in **Figure 1** (> 55 consecutive days) was also a point of concern for stakeholders, specifically, that salinity > 10 for > 55 consecutive days could potentially damage the existing *Vallisneria* community and therefore, is too long of a period for triggering an MFL exceedance.

Stakeholders recommended replacing the proposed "daily average salinity > 10 for > 55 consecutive days" criterion with a "30-day moving average salinity > 10 "criterion". To test this recommendation, the District performed additional analysis of modeling results to compare the effects of each of the two salinity criteria on the (1) occurrence of high salinity events alone; and (2) incidence of combined flow exceedance and high salinity events, both with future conditions and with and without the Caloosahatchee River (C-43) West Basin Storage Reservoir (C-43 Reservoir) project in place.

Table 3 shows that a change to the 30-day moving average salinity criterion increases the occurrence of high salinity events in the future, both with and without the reservoir (25 versus 30 and 26 versus 42, respectively). However, the average number of days per salinity event declines (137 versus 127 and 162 versus 116, respectively) as does average salinity during events (13.82 versus 13.4 and 19.6 versus 17.9, respectively).

Table 3. High salinity event comparison between the > 55-consecutive day salinity criterion and a 30-day moving average salinity criterion, with future conditions, with and without the C-43 Reservoir project.

Salinity Duration Criterion	Model Scenario	Number of High Salinity Events	Average Days	Average Salinity
>55 Consecutive Days	FCBO (without project)	26	162	19.6
	FCBW400 (with project)	25	137	13.82
30-Day Moving Average	FCBO (without project)	42	116	17.9
	FCBW400 (with project)	30	127	13.4

Table 4 shows that changing to a 30-day moving average salinity criterion results in no difference in the incidence of combined flow exceedance and high salinity events in the future, both with and without the reservoir. However, due to an apparent reduction in the average number of days per salinity event and the average salinity during events, which is more beneficial and protective of indicator species in the CRE, staff recommended the salinity criterion with a 30-day moving average be incorporated in the draft MFL rule (**Figure 2**). This draft MFL rule with revised criteria was brought before the District Governing Board on July 12, 2018, for authorization to move forward with MFL rule revision through publication of a Notice of Proposed Rule.

Table 4. Combined flow exceedance and high salinity event comparison between the > 55-consecutive day salinity criterion and a 30-day moving average salinity criterion, with and without the C-43 Reservoir project.

Duration Criterion	Model Scenario	Number of Combined Flow Exceedance and High Salinity Events
> 55 Consecutive Days	FCBO (without project)	26
	FCBW400 (with project)	6
30-Day Moving Average	FCBO (without project)	26
	FCBW400 (with project)	6

Position of the Low Salinity Zone and High Salinity Events:

A concern was raised about potential negative effects of high salinity events on CRE ecological indicators. To address this concern, the District conducted an isohaline position analysis during the dry season in the CRE with the future condition, with and without the C-43 Reservoir project, and evaluated the effects of isohaline position on *Vallisneria* and zooplankton indicator species.

An isohaline is a line that connects all points of equal salinity across an estuary, and thus represents the boundary of a particular salinity zone. Isohalines fluctuate upstream and downstream in an estuary with fluctuations in freshwater inflow, tidal cycles, and meteorological phenomena (e.g. rainfall events, winds, and storms). Particular isohalines indicate desirable salinity conditions for estuarine organisms (Jassby et al. 1995). The District's analysis involved two different isohalines: a salinity of 5 for selected zooplankton species (denoted as X_5) and a salinity of 10 for *Vallisneria* habitat (denoted as X_{10}). The analyses described below shows that the C-43 Reservoir project is beneficial to the low salinity zones (X_5 and X_{10}) for both indicator species.

X_5 Isohaline Analysis for Zooplankton

Zooplankton assemblages often shift upstream with their food resources (phytoplankton) while remaining within favorable salinity zones (Flannery et al. 2002). However, there is the possibility of habitat compression and/or impingement if upstream movement of planktonic assemblages is bounded by a water control structure (Crowder 1986, Tolley et al. 2010). Habitat compression is the crowding of organisms into a relatively confined space (Crowder 1986, Copp 1992, Eby and Crowder 2002), which may result in increased predation and competition for limited food sources. Some organisms may be forced to utilize habitat that is physiologically suboptimal, potentially reducing growth and survival (Petersen 2003). Many estuaries have water control structures (e.g. dams) that regulate freshwater inflow. At times of reduced inflow, these structures can impinge organisms and block their upstream movement.

The S-79 structure is located at the head of the CRE where fresh water is discharged (0 kilometer [km] point). The geomorphology of the CRE from 0 to 12 km from S-79 is very narrow and deep. Habitat compression and/or impingement can occur to organisms in this portion of the CRE during low flow conditions. Almost all taxa investigated in the 2017 reevaluation (the exception was *Menidia* sp.) experienced habitat compression if their center of abundance was < 12 km downstream of S-79. Further, at very low flows during the dry season, some species, notably juvenile bay anchovies (*Anchoa mitchilli*) and their mysid (*Mysida* sp.) prey, can become impinged on the S-79 structure and when this occurs they are prevented from moving further upstream (Tolley et al. 2010). Impingement against a water control structure such as S-79 can exacerbate the effects of habitat compression. The fresh water habitat of these organisms is being reduced because it is being compressed against a structure (S-79).

The X_5 portion of the District's isohaline position analysis, during the dry season, modeled the following: (1) effect of the C-43 Reservoir (MFL recovery strategy) on the position of the X_5 isohaline in the CRE (**Figure 5**); (2) the potential for habitat compression and impingement in the upper CRE based on the number of days X_5 is < 12 km from S-79, analyzed both with and without the C-43 Reservoir project (**Figure 6**); and (3) the effect of the C-43 Reservoir on the number of compression events in the upper CRE using eight selected zooplankton species inhabiting the estuary from 0 to 12 km downstream of S-79 (**Table 5**).

The analysis indicated, with 95% confidence, that the location of X_5 would shift 3 km downstream with the reservoir (**Figure 5**) versus without the reservoir. This downstream shift of the isohaline is expected to reduce the possibility of impingement at S-79.

The analysis revealed there were 3,709 days when X_5 was < 12 km from S-79 out of a total of 14,243 days over the 39-year period of record analyzed from January 1, 1967, to December 31, 2005 (**Figure 6**). With the reservoir, the number of days the X_5 is < 12 km from S-79 is reduced by 45% (from 3,709 to 2,025 days).

The analysis also indicated a with-reservoir reduction in the number of habitat compression events in the upper CRE, ranging from 38 to 92%, among all eight species analyzed (**Table 5**). Seven of these species have reductions predicted in the range of 83 to 92%.

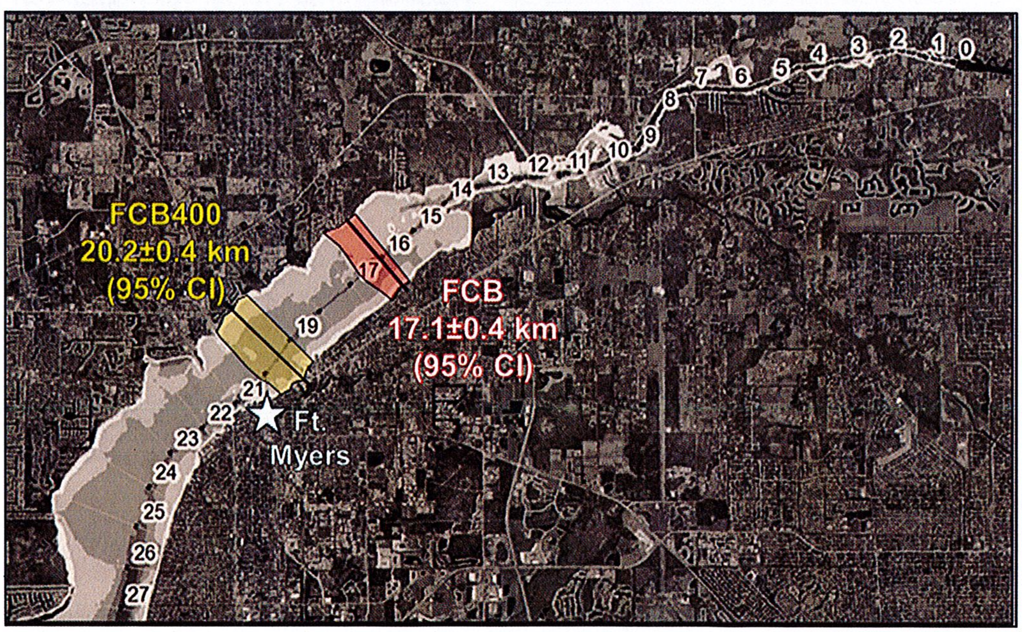
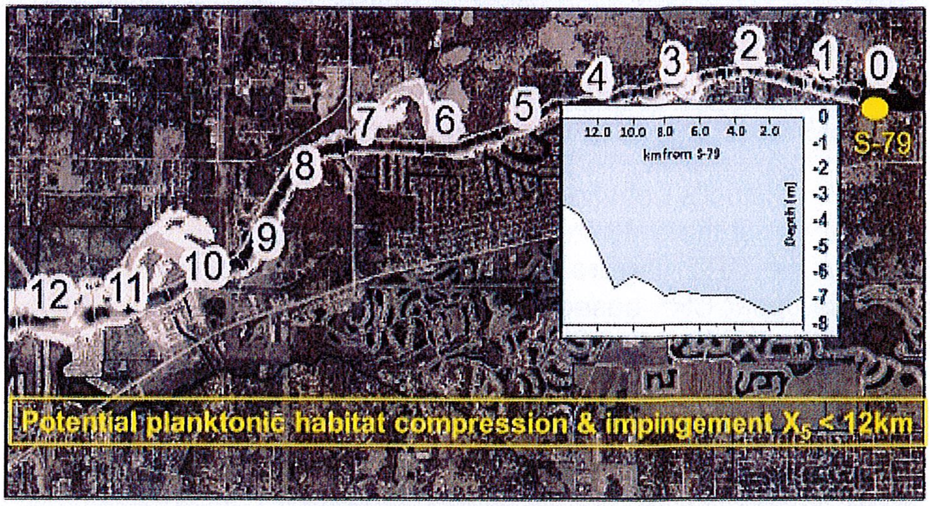


Figure 5. Location of the X_5 isohaline in the upper CRE during the dry season with (FCB400) and without (FCB) the C-43 Reservoir project.



X_5 < 12 km from S-79 (number of days of 14,243 total)

	FCB	FCB400	Difference
Less than 12 km	3709	2025	45.4% Reduction

Figure 6. Number of days the X_5 isohaline is < 12 km from S-79 during the dry season with (FCB400) and without (FCB) the C-43 Reservoir project. Habitat compression and impingement are inverse to distance from S-79.

Table 5. Effect of the C-43 Reservoir project on incidence of habitat compression events for eight planktonic species located 0 to 12 km downstream of S-79 during the dry season. A habitat compression event occurs when the center of abundance is < 12 km.

Species	Total Number of Compression Events or Percent Change		
	Without Reservoir	With Reservoir	Percent Change (Reduction)
Lironeca spp. (Isopod)	29	4	86.2
Edotia tribola (Mysid)	29	5	82.8
Americamysis almyra (Mysid)	50	31	38.0
Clytia spp. (Jellyfish)	28	4	85.7
Bowmaniella brasiliensis (Mysid)	26	4	84.6
Gobiidae preflexion larvae (Goby Larvae)	24	2	91.7
Anchoa mitchili (Common Anchovy)	54	7	87.0
Mnemiopsis leidyi (Comb Jelly)	54	7	87.0

X_{10} Isohaline Analysis for Tape Grass Habitat

During the dry season, freshwater inflow to the CRE can be so low that salt water migrates up to the S-79 structure, truncating the salinity gradient within the CRE. *Vallisneria* is an important indicator of elevated salinity in the CRE because it is sensitive to salinities > 10. During low flow periods, this habitat-forming species can become stressed or experience mortality if high salinity conditions in the CRE persist. The Ft. Myers salinity monitoring station, which is located approximately 21 km downstream of S-79, is considered the downstream boundary of suitable *Vallisneria* habitat as this is where salinity begins to frequently exceed 10.

The X_{10} portion of the isohaline position analysis modeled, during the dry season, the (1) effect of the C-43 Reservoir on the position of the X_{10} isohaline in the CRE (**Figure 7**); and (2) potential for impact to *Vallisneria* habitat in the CRE based on the number of days X_{10} is < 21 km from S-79, analyzed both with and without the C-43 Reservoir project (**Figure 8**).

The analysis indicated, with 95% confidence, that the location of X_{10} would shift 4 km downstream with the reservoir (**Figure 7**) versus without the reservoir. This downstream shift of the isohaline is expected to improve habitat conditions for *Vallisneria* and reduce the potential for stress during low flow conditions.

The analysis also revealed there were 3,914 days when X_{10} was < 21 km from S-79 out of a total of 14,243 days over the 39-year period of record analyzed from January 1, 1967, to December 31, 2005 (**Figure 8**). With the reservoir, the number of days the X_{10} is < 21 km from S-79 is reduced by 37% (from 3,914 to 2,458 days).

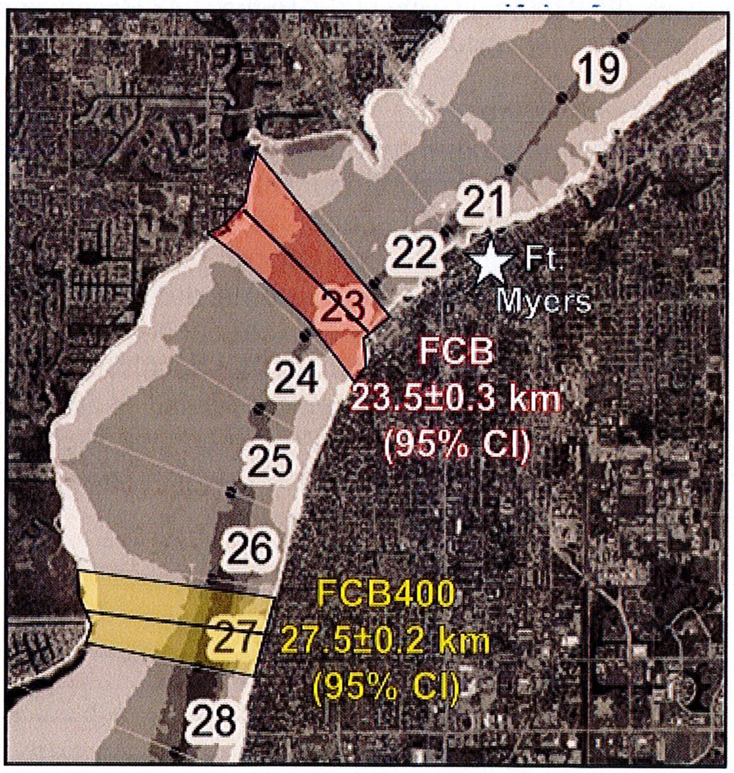
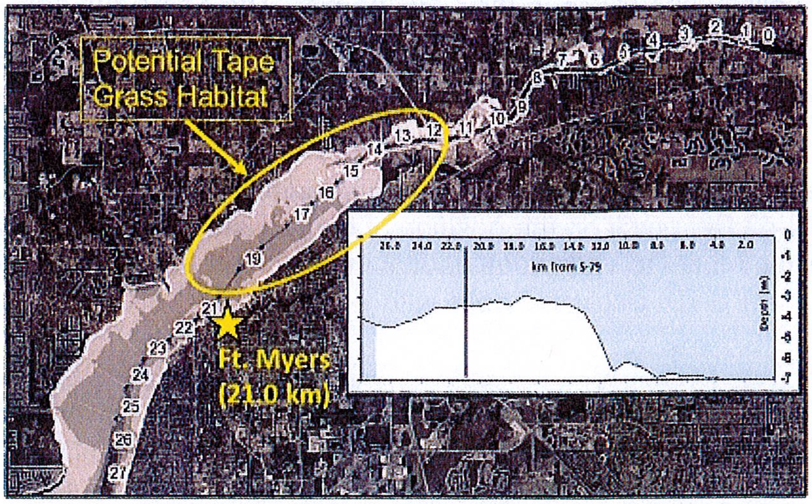


Figure 7. Location of the X_{10} isohaline in the CRE, during the dry season with (FCB400) and without (FCB) the C-43 Reservoir project.



X_{10} < 21 km from S-79 (number of days of 14,243 total)

	FCB	FCB400	Difference
Less than 21 km	3914	2458	37.2% Reduction

Figure 8. Number of days the X_{10} isohaline is < 21 km from S-79, during the dry season, with (FCB400) and without (FCB) the C-43 Reservoir project. Impact to *Vallisneria* habitat is inverse to the distance from S-79.

Model Animations for X_{10} Isohaline

The District also developed animated graphics, using Tecplot animation software using a daily salinity from the Curvilinear Hydrodynamic Three-Dimensional Model (CH3D), to show the movement of X_{10} within the CRE under different climatic conditions and with and without the C-43 Reservoir project. Animations were created for five different timeframes. Four of the timeframes were the extreme drought events of 1976–1977, 1981–1982, 1989–1990, and 2000–2001 when exceedance events were predicted to occur ("worst case" scenarios). The fifth timeframe was developed for the water year in 1993, to represent normal conditions during a typical rainfall year. All of the animations were made available to the public on the District MFL web page. **Figure 9** is a screenshot of one day in the 1976–1977 model, January 16, 1977, which shows the beneficial effect of the C-43 Reservoir on the location of the X_{10} isohaline.

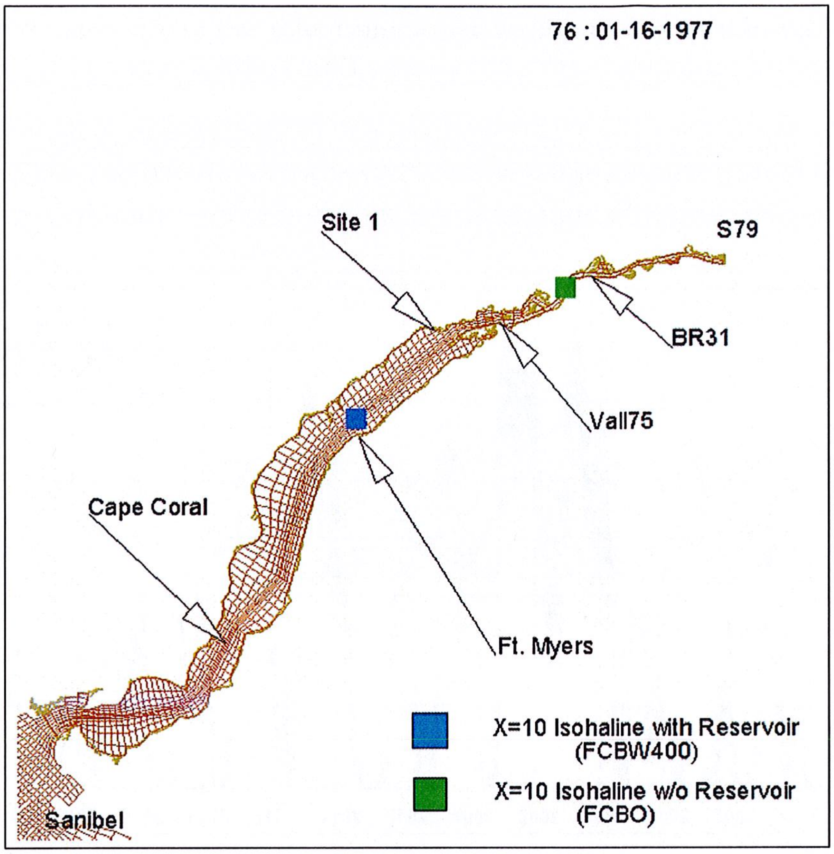


Figure 9. Location of the X_{10} isohaline on January 16, 1977, modeled with (FCBW400) and without (FCBO) the C-43 Reservoir project.

Single, Daily Average Salinity > 20 Criterion for MFL Violations:
Stakeholders expressed a concern about the proposed deletion of the single daily salinity > 20 criterion from the MFL rule. To address this concern, the District performed additional analyses, including modeling, as well as analysis of observed data, to determine what effect, if any, deleting the criterion would have on detecting MFL exceedances and protecting the resource.

Modeling
Model simulations were conducted, with and without the C-43 Reservoir project, using a 39-year period of record from January 1, 1967, to December 31, 2005, and both the single daily average salinity > 20 criterion, and the 30-day average salinity > 10 for > 55 consecutive days criterion. In both model simulations, the single daily average salinity > 20 criterion was never exceeded before the 30-day average salinity > 10 for > 55 consecutive days criterion.

Observed Data
The District analyzed measured, observed MFL compliance data generated since the initial adoption of the MFL rule in 2001 to determine when the single daily average salinity criterion and 30-day average salinity criterion of the adopted MFL rule were exceeded or violated. **Figure 10** shows that exceedance of the 30-day average salinity criterion (green dots) always occurred before exceedance of the single daily average salinity criterion

(yellow dots). Most of the exceedances associated with the single daily average salinity criterion occurred during extreme drought events (2007–2008 and 2011).

The results of the modeling performed (above) and observed data analyses in this section indicate that the single daily average salinity > 20 criterion provided no additional resource protection for the CRE and was, therefore, not included in the draft MFL rule (**Figure 2**).

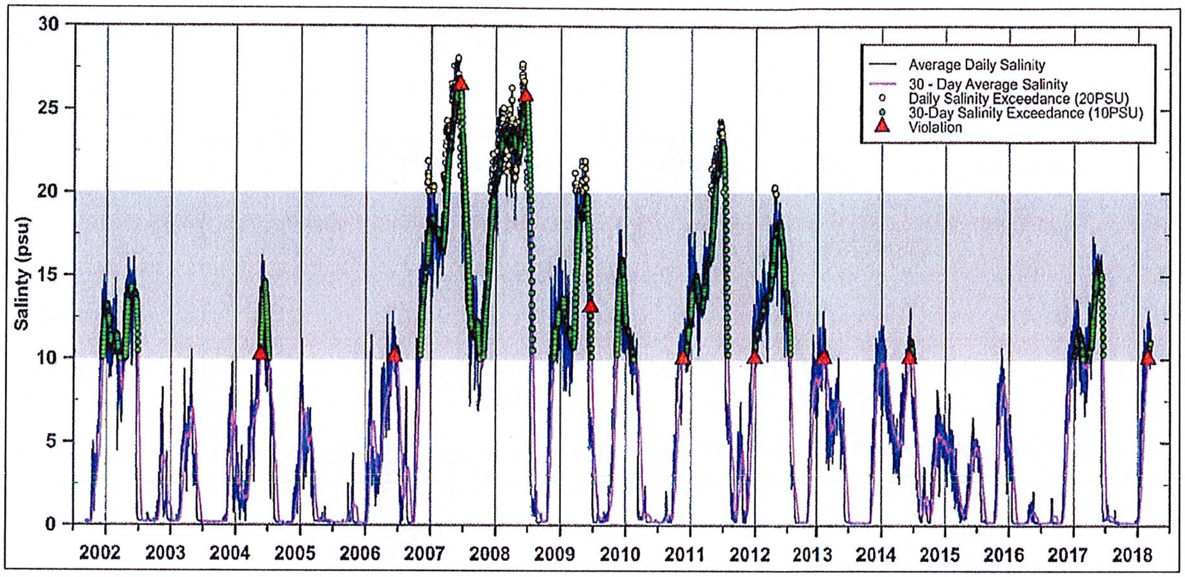


Figure 10. MFL salinity criteria exceedances and violations since criteria adoption in 2001.

District Salinity Data versus Other Sources of Salinity Data:
The 2001 MFL rule mandates collection of salinity data, from the District's Ft. Myers salinity monitoring station (defined in the rule), for the purpose of assessing compliance with the rule (Subsection 40E-8.221(2), F.A.C.). Salinity data from this station were also used in the 2017 MFL reevaluation and the additional analyses described in this document. Stakeholders raised a concern about potential differences in the salinity data from the Ft. Myers salinity monitoring station and salinity data from other nearby salinity monitoring stations in the CRE that are maintained by a different entity. To address this concern, the District made a comparison of salinity data from the Ft. Myers salinity monitoring station to salinity data from the Sanibel Captiva Conservation Foundation's (SCCF) Fort Myers Yacht Basin salinity monitoring station, for the period June 15, 2015 to present. The two salinity monitoring stations are located very close to one another. The SCCF's monitoring station is located more toward the center of the CRE while the District's monitoring station is located closer to the shoreline (both are located near 21 km from S-79). Even with these minimal locational differences, the salinity data from the two stations tracked very closely (**Figure 11**) over the period June 15, 2015, to present. This indicates the likelihood that any data-related differences in analyses conducted with data from either of the two stations would be minimal and does not invalidate the District's MFL reevaluation analyses.

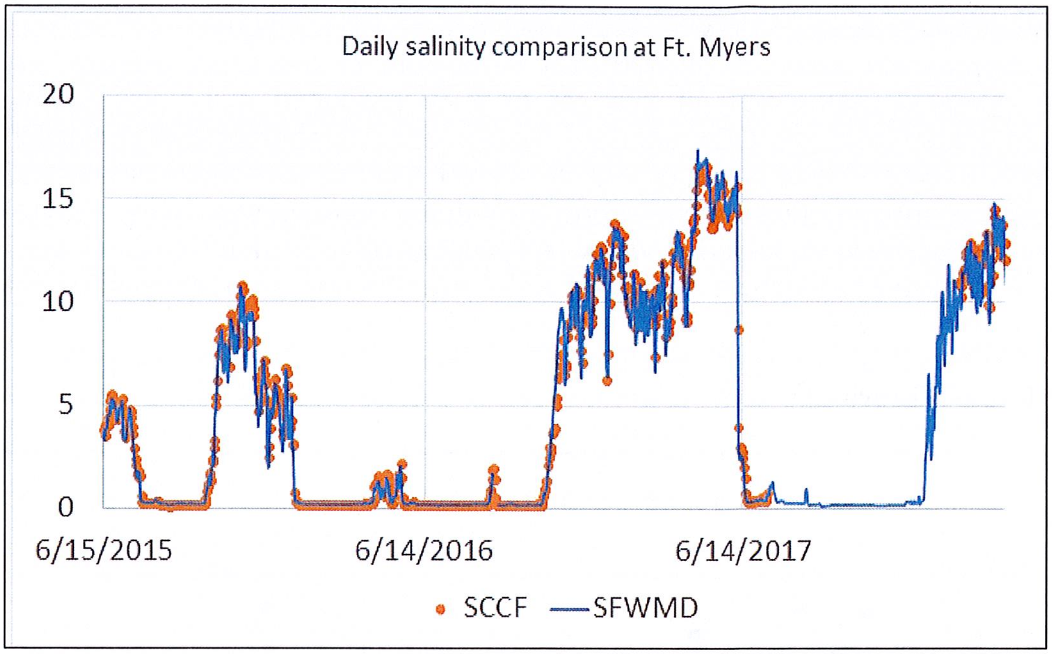


Figure 11. Comparison of salinity data from the SFWMD Ft. Myers salinity monitoring station versus salinity data from the Sanibel Captiva Conservation Foundation Fort Myers Yacht Basin salinity monitoring station, from June 15, 2015, to present.

Effects of LORS2008 on the Position of X_{10} Isohaline:

There was a concern expressed that the position of the X_{10} isohaline changed with implementation of the current Lake Okeechobee Regulation Schedule (LORS2008). In response, the District conducted an analysis using observed data collected between 2008 and 2017 to determine if the X_{10} isohaline was upstream or downstream of the Ft. Myers salinity monitoring station during that period of time. Modeling data were unavailable to evaluate the exact position of the isohaline. The Ft. Myers salinity monitoring station is located at ~21 km from S-79. The results of the analysis revealed that X_{10} was constantly upstream of the Ft. Myers salinity monitoring station (< 21 km from S-79) during severe drought events that occurred in 2007–2008 and 2010–2011 dry seasons. During the dry seasons from 2008 to 2017, the X_{10} isohaline on average is located downstream of the Ft. Myers salinity monitoring station 58% of the time.

Zooplankton Recovery from Habitat Compression Events:

The District conducted an analysis, based on a previous analysis conducted by Dr. Peter Doering (SFWMD 2018), to evaluate the time period needed for recovery of zooplankton from habitat compression in the upper CRE following increased flow from S-79.

CRE zooplankton experience habitat compression if their center of abundance (COA) is < 12 km downstream of S-79 (SFWMD 2018). Therefore, the analysis involved estimating how long it would take for the COA of the predatory jellyfish *Clytia* spp. that has experienced habitat compression during a prolonged period of no flow from S-79 (minimum of 30 days), to move ≥12 km downstream of S-79 after a surface water release from S-79. *Clytia* spp. was chosen as the test subject because it is a zooplankton predator species that occurs < 30 km from S-79 (SFWMD 2018). Its location is also highly correlated with a 50-day lagged flow indicating it is a sensitive indicator of flow rate. As part of the analysis, an equation was developed to show the relationship of flow from S-79 after a compression event to downstream movement of the COA (**Figure 10**). The equation revealed that a flow of 300 cfs at S-79 produced a 1.1 km downstream movement of the *Clytia* spp. COA per day. Therefore, if this species was impinged at the S-79 structure when flow releases of 300 cfs started, it would take approximately 12 days for the COA to move downstream beyond the habitat compression point (12 km). The results of the analysis indicated a weak relationship of S-79 flow to *Clytia* spp. COA movement ($r^2 = 0.41$) and could not be linked back to the definition of significant harm in Subsection 40E-8.021(31), F.A.C. ("more than two years to recover"). Therefore, the results of this analysis were not used to justify revising the duration component of the draft MFL rule (**Figure 2**).

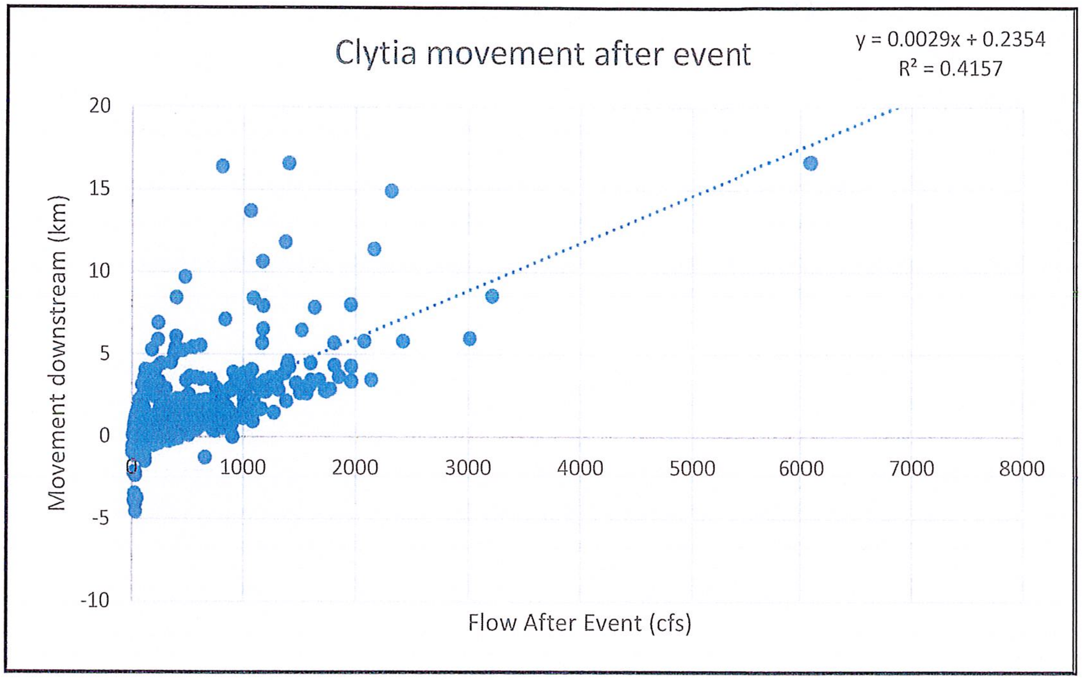


Figure 12. Relationship of *Clytia spp.* downstream movement to flows of 300 cfs at S-79.

Indicator Monitoring in the CRE:

More information was requested about indicator monitoring being conducted in the CRE, particularly with regard to oysters and submerged aquatic vegetation (SAV). Oyster and SAV monitoring is being conducted by the District throughout the CRE. **Figure 13** shows the current spatial extent and location of monitoring sites for oyster and SAV monitoring and **Tables 6** and **7** provide the current sampling frequency and parameters for each type of monitoring.

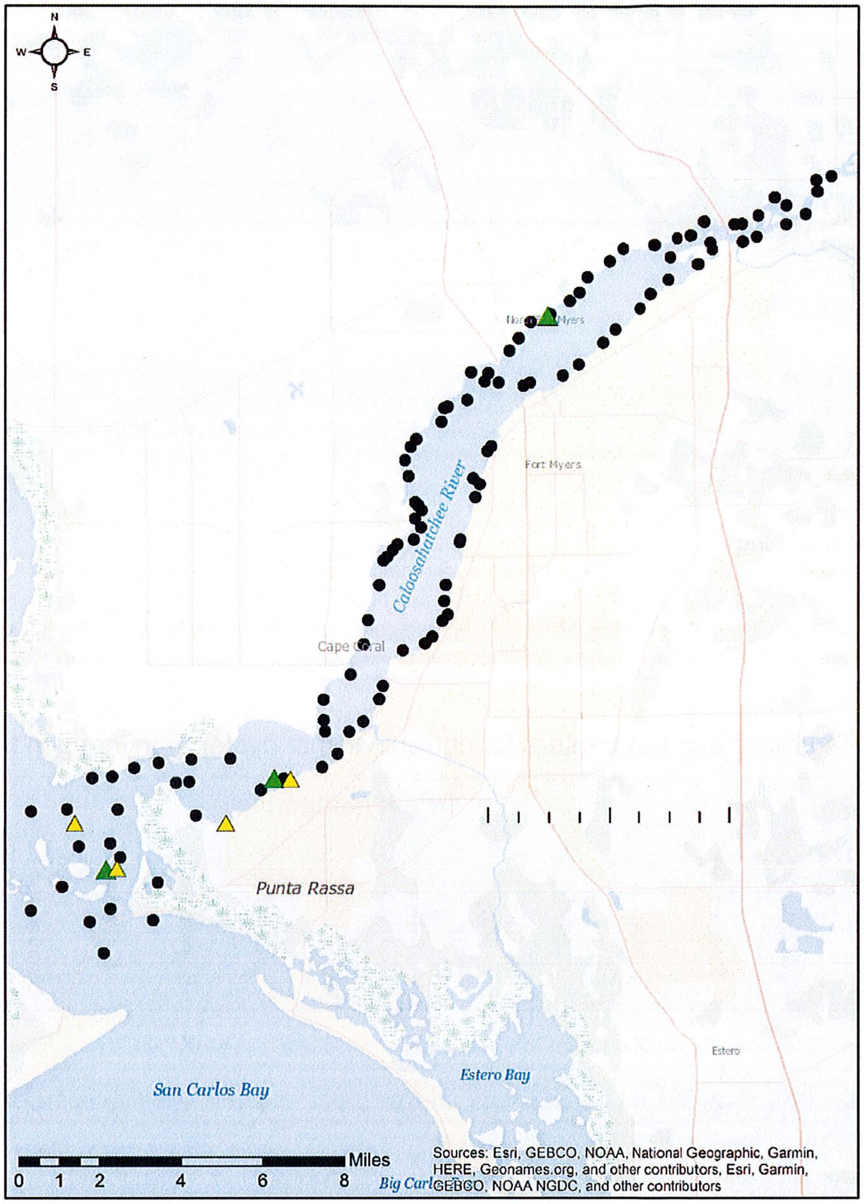


Figure 13. Sampling locations of oyster and SAV monitoring throughout the CRE. Yellow triangles – oyster monitoring sites; green triangles – SAV permanent transect sites; and black dots – representative SAV sampling points (from summer 2018). SAV sampling points vary per sampling event, performed twice annually estuary-wide.

Table 6. Frequency and parameters for current District SAV monitoring in the CRE.

	March	April	May	June	July	August	September	October	November
Estuary-wide surveys: species-specific cover and abundance, canopy height		X						X	
Permanent transects: species-specific cover and abundance, shoot density, canopy height	X		X	X	X	X	X		X
Permanent transects: above and below ground biomass			X				X		
Environmental parameters	X	X	X	X	X	X	X	X	X

Table 7. Frequency and parameters for current District oyster monitoring in the CRE.

	Oyster Monitoring											
Parameter	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Density Counts			X			X			X			X
Reproductive Stage	X	X	X	X	X	X	X	X	X	X	X	X
Disease	X	X	X	X	X	X	X	X	X	X	X	X
Spat Recruitment	X	X	X	X	X	X	X	X	X	X	X	X
Growth & Survival	X	X	X	X	X	X	X	X	X	X	X	X
Water Quality	X	X	X	X	X	X	X	X	X	X	X	X
Reports		A	Q			Q			Q			

A – annual and Q – quarterly.

Monitoring of other ecological indicators, such as ichthyoplankton, benthic fauna, and zooplankton species, are not performed on a routine basis by the District. Monitoring for these indicators that supported the 2017 MFL reevaluation is described in Components 4 (zooplankton), 5 (ichthyoplankton), and 6 (macrobenthic community) in Chapter 5 and Appendix A of the January 30, 2018, Technical Document. A monitoring program for the next MFL reevaluation is under development and is expected to be designed to measure existing and future ecological responses from a suite of indicators with increased flows associated with the C-43 Reservoir.

Summary

This compilation of additional scientific analyses performed subsequent to publication of the January 30, 2018, Technical Document, combined with the previous scientific studies, monitoring, modeling, and technical evaluations described in the chapters and appendices of the Technical Document, represents the best available information to support the proposed revised MFL criteria for the Caloosahatchee River MFL rule (Subsection 40E-8.221(2), F.A.C.) shown in **Figure 2**.

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